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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#13
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11/18/03

IN RE THE APPLICATION OF	)	Examiner: Huy D. Nguyen
	)	
Edwards et al.	)	Group Art Unit: 2681
	)	
SERIAL NO.: 09/512,909	)	
	)	
FILED: February 25, 2000	)	
	)	Docket No.:
FOR: A WIRELESS TERMINAL DIVERSITY SCHEME	)	920476-904440(1568.1)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to "Commissioner of Patents, PO Box 1450, Alexandria VA 22313-1450, on October 31 , 2003..

Name of person signing: Kathy Kurek
Signature Kathy Kurek

SUPPLEMENT TO RESPONSE FILED OCTOBER 9, 2003

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Honorable Commissioner for Patents
United States Patent and Trademark Office
PO Box 1450
Alexandria VA 22313-1450

Dear Sir:

In supplemental to the response filed October 9, 2003, submitted herewith is a claim for priority and the certified copy of the underlying UK application, as set forth in the referenced response.

DATE: October 30, 2003

Respectfully submitted,

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Patents Form 1/77

Patents Act 1977
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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

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1.	Your reference	KR EDWARDS 14
2.	Patent application number *(The Patent Office will fill in this part)*	**9626549.1** 20 DEC 1996
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)* Patents ADP number *(if you know it)* If the applicant is a corporate body, give the country/state of its incorporation	Northern Telecom Limited World Trade Center of Montreal 380 St. Antoine Street West 8th Floor Montreal Quebec H2Y 3Y4 Canada PATENT OFFICE 20 DEC 1996 LONDON 61559 CC 001 Quebec Canada
4.	Title of the invention	A WIRELESS DIVERSITY SCHEME
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	E.J. Humphrey-Evans Nortel Patents London Road Harlow Essex CM17 9NA 6993460002
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country — Priority application number *(if you know it)* — Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application — Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	

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Description	7
Claim*(s)*	2
Abstract	1
Drawing*(s)*	5

3

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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination and search *(Patents Form 9/77)*

Request for substantive examination *(Patents Form 10/77)*

Any other documents *(please specify)*

11. I/We request the grant of a patent on the basis of this application.

Signature E.J. Humphrey-Evans

E.J. HUMPHREY-EVANS - AGENT FOR THE APPLICANTS

Date 20/12/96

12. Name and daytime telephone number of person to contact in the United Kingdom E.J.Humphrey-Evans - 01279 405677

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A WIRELESS DIVERSITY SCHEME

Field of the Invention

The present invention relate to wireless communication systems and in particular relates to a fixed wireless diversity scheme.

Background of the Invention

In a typical mobile cellular radio network both capacity (maximum number of users) and coverage (area covered from one base station site) are limited by the system uplink (reverse link) performance. This is especially true where either uplink transmitter power is limited (by, inter alia, battery life considerations) or interference. Systems employing Code Division Multiple Access (CDMA) techniques with orthogonal down link (forward link) and quasi orthogonal uplink are generally uplink capacity limited due to other user interference. It is, therefore, usual to employ diversity techniques at the base station receiver (uplink) but not on the down link.

In a fixed wireless access system terminals are usually mains powered and battery backups provided by larger electrical cells than would be viable to put into a handset. Thus it is possible to use very much higher power transmitters in fixed access than mobile hand portables (e.g. 2W compared with 200 mW).

Since fixed wireless access terminals are static or move infrequently, for example, between the rooms of a subscribers residence, some of the techniques applied to mobile down links, such as interleaving, are relatively ineffective. In these cases down link capacity and coverage can potentially be the limiting factors in deployment. Diversity techniques are well established and known to help this situation but have generally been considered too complex to implement in a low cost terminal.

Object of the Invention

It is an object of the invention to provide radio link diversity for a fixed wireless system.

Description of the Invention

In accordance with a first aspect of the invention, there is provided a fixed wireless access arrangement comprising at least one base station in communication an out station, wherein the out station has at least two antennas, and wherein the signals from the antennas are assessed relative to a threshold and wherein the strongest output signal is selected and wherein the output signals from the other antenna is selected only when it contributes to the carrier-to-noise ratio.

Preferably, the antennas of the system are separated by distance, whereby spatial diversity is employed to differentiate signals. Alternatively, the antennas of the system have a different polarisation, whereby polarisation diversity is employed to differentiate signals. The system could incorporate both spatial and polarisation diversity. Hysteresis can be employed to prevent rapid switching. A rake receiver may be employed to combine signals which are spatially separated. Alternatively, MLSE (Maximum Likelihood Sequence Estimator - e.g. Viterbi algorithm) demodulation is employed and the delay, τ, is set to a period corresponding to a symbol period. In the case of signal reception

employing a rake receiver, the multi-path metric can be set so that only one antenna can be employed.

In accordance with a further aspect of the invention, there is provided a method of operating a fixed wireless access arrangement, wherein each outstation comprises at least two antennas;
wherein the method comprises the steps of
assessing the signal strength relative to a threshold value; and in addition to employing the signals received from the antenna with the largest signal, employing the signals received from each subsequent antenna are only when the respective subsequent antenna contributes to the carrier-to-noise ratio of the system.

In accordance with a still further aspect of the invention, there is provided an outstation comprising at least two antennas and wherein the signals for each antenna are assessed relative to a threshold value and wherein secondary antennas are employed only when the secondary antenna contributes to the carrier-to-noise ratio of the system.

Brief Description of the Figures

In order to allow a greater understanding of the invention, reference shall now be made to the Figures, wherein:

Figure 1 shows a typical multi-path, fixed wireless scenario;

Figure 2 shows a first embodiment of the invention;

Figure 3 shows a first scenario of operation;

Figure 4 shows a second scenario of operation employing a threshold detector;

Figure 5 shows a second embodiment of the invention; and,

Figure 6 shows one form of antenna arrangement

Detailed description of the Invention

Referring now to Figure 1, a typical deployment of a multi-path signal environment fixed wireless system, wherein an out station having a single antenna could remain in a signal null for long periods of time. In this case, because of the existence of a multi-path environment, the reception of the down link orthogonality has been compromised to a "quasi orthogonal" situation.

The maximum capacity of the system, Nu, will then be approximated by:-

In the uplink, $Nu \approx \frac{W/R}{Eb/No}$

and;
in the down link, $Nu \approx \frac{W/R}{\alpha\, Eb/No}$ or maximum number of codes,

whichever is the lower

where W = Spread Bandwidth (chip rate)
R = Data rate
Eb/No = Bit energy spectral density
α = Orthogonality factor (range: 0 - 1)

For quasi orthogonality $\alpha = 1$;
for perfect orthogonality $\alpha = 0$.

Generally the uplink bit energy spectral density (Eb/No) required for converting operation will be lower than the down link for the same bit error rate (BER) in the static environment for a typical CDMA system. Thus when orthogonality has been compromised it is essential to reduce the bit energy spectral density required on the downlink.

A first embodiment of the invention is shown in Figure 2 and provides a simple to implement downlink diversity scheme. The arrangement 20 comprises two antennas, 22, 24. Each antenna receives a different

signal due to the multi-path environment. These signals are then amplified by low noise amplifiers 24 to provide a low noise front end to the receiver, 26. One signal is time delayed by delay means 28 by a period τ, where τ is the chip rate or the inverse of the Spread bandwidth before being combined by a two-way power combiner, 30, the operation of which is controlled by control means 34. The combiner scheme makes use of the ability of RAKE receivers to combine two time delayed multi-paths in an optimal manner. Switch arrangement 32 includes signal strength measurement devices.

The signal strength on both antennas is measured by the signal strength measurement devices and the switch corresponding to the strongest input selected. The switch on the other antenna is selected if, when the signal from the other antenna is added to the signal of the first antenna, the overall signal strength (carrier to noise) would increase. A method similar to a combiner algorithm could be employed, such as the algorithm disclosed in UK Patent Application GB9421538.1, wherein only signals which contribute to the overall signal-to-noise ratio are utilised.

The addition of the switch and control elements improves the combiner performance over that of the simple combiner by avoiding the case where one antenna being in a power null would cause up to 3dB loss in sensitivity. By reducing the required bit energy spectral density using diversity both coverage and capacity are improved.

In a preferred case, a means 36 for evaluating the degree of multi-path (delay spread metric for RAKE) in the environment could be used to disable the selection of the second antenna in the case that orthogonality on the downlink has not been compromised by the channel. If this control was not present the diversity arrangement would compromise orthogonality by adding a multi-path equal in strength to the first path one chip away. This would turn perfect orthogonality ($\alpha = 0$) into compromised orthogonality ($\alpha = 0.5$). In practice, however, this is unlikely to be a drawback in deployment. It is expected that only very few links will have very good orthogonality and the majority will benefit by reduction in Eb/No by more than the any small increase in α

introduced by the simplest embodiment. Alternatively, MLSE (Maximum Likelihood Sequence Estimator - e.g. Viterbi algorithm) demodulation is employed and a delay, τ, is set to a period corresponding to a symbol period. In the case of signal reception employing a rake receiver, the multi-path metric can be set so that only one antenna can be employed.

The range can be increased directly by the lower bit energy spectral density for dB and capacity can be increased by the reciprocal of the bit energy spectral density in linear terms. That is, a 3dB halving of bit energy spectral density increases capacity by up to a factor of 2. By switching only when the second antenna directly contributes to the carrier to noise ratio there is no or little reduction in the signal strength, that is normally associated with this type of diversity when one antenna is in a power null.

Since the fixed channel is generally varying at a slower rate than is encountered in mobile radio situations, the RAKE is not presented with switching transients that would otherwise be present. It is to be noted that if the arrangement includes a simple switch diversity scheme alone, step changes in the RAKE input would be produced, which would be highly undesirable.

In such a case, the operation would be similar to that as shown in Figure 3: A1 begins off largest and then fades whereas A2 begins at an insignificant level and becomes the dominant signal. So at T=0 only A1 is selected. As A2 increases at T=1 it is also selected and both remain selected for T=2 and T=3. Finally at T=4 , A1 no longer contributes to C/N and is deselected and only A2 selected.

In the second example, shown in Figure 4, two levels of threshold are used to provide hysteresis to the process. This could also be applied in the case of the first example to reduce the impact of change on the RAKE receiver if it was found that two or more signals were present that caused frequent switching. Depending upon RAKE performance a threshold could be chosen to optimise overall performance.

The present invention is also applicable to Time Division Multiple Access) TDMA based systems if the delay is increased to a symbol period (≈ 3.7 μs in GSM) and switching performed during the "dead" points of the slots (i.e. when not actively receiving). This last point is a key difference between CDMA and TDMA. In TDMA this difference is usefully employed and the antenna selection may be switched without disturbing the receiver processing at such times. Thus in the TDMA embodiment a control from the timing circuitry is used to gate or clock the selection process to prevent a change during a TDMA frame. This is shown in Figure 5. In the terminal block diagram 50 for a CDMA scheme, there are many elements common with those employed for a TDMA scheme, as shown in Figure 2. The receiver box 52 differs from that of receiver box 26 in that control 34 leads to a switch 54 and timing circuitry 56 which provide timing information for a demodulator 58. The demodulator receives signals from summing means 30. Figure 5a shows the switching function of switch 54.

Figure 6 shows a possible antenna set-up where the orientation of vertical and horizontal antennas is such that space and polarisation diversity techniques can be employed.

Claims

1. A fixed wireless access arrangement comprising at least one base station in communication an out station, wherein the out station has at least two antennas, and wherein the signals from the antennas are assessed relative to a threshold and wherein the strongest output signal is selected and wherein the output signals from the other antenna is selected only when it contributes to the carrier-to-noise ratio.

2. A fixed wireless access arrangement according to claim 1 wherein the antennas of the out station are separated by distance, whereby spatial diversity is employed to differentiate signals.

3. A fixed wireless access arrangement according to claim 1 wherein the antennas of the out station have a different polarisation, whereby polarisation diversity is employed to differentiate signals.

4. A fixed wireless access arrangement according to claim 1 wherein the antennas of the out station incorporates both spatial and polarisation diversity.

5. A fixed wireless access arrangement according to claim 1, wherein Hysteresis is employed to prevent rapid switching.

6. A fixed wireless access arrangement according to claim 1 wherein a rake receiver is employed to combine signals which are spatially separated.

7. A fixed wireless access arrangement according to claim 1 , wherein MLSE demodulation is employed and the delay, τ, is set to a period corresponding to a symbol period.

8. A fixed wireless access arrangement according to claim 1 wherein a rake receiver is employed to combine signals which are spatially separated, and wherein, the multi-path metric can be set so that only one antenna is employed.

9. A method of operating a fixed wireless access arrangement, wherein each outstation comprises at least two antennas; wherein the method comprises the steps of: assessing the signal strength relative to a threshold value; and in addition to employing the signals received from the antenna with the largest signal, employing the signals received from each subsequent antenna are only when the respective subsequent antenna contributes to the carrier-to-noise ratio of the system.

K Edwards 14 US

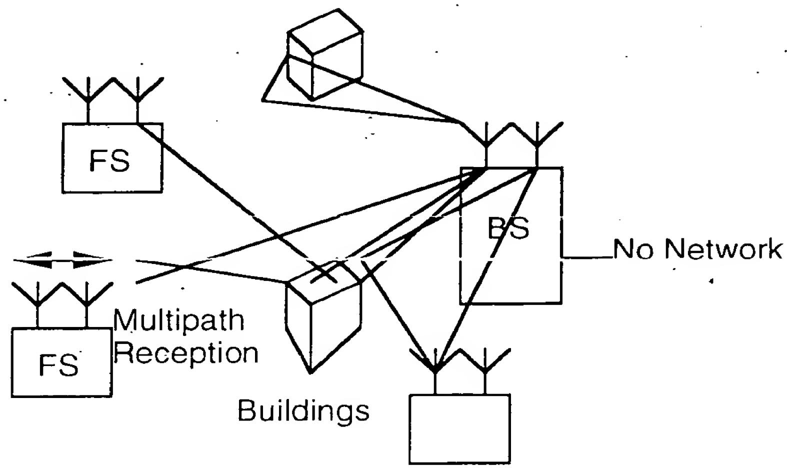
Figure to Accompany Abstract
Figure 2

A WIRELESS DIVERSITY SCHEME

Abstract of the Invention

The present invention relate to wireless communication systems and in particular relates to a fixed wireless diversity scheme. Diversity techniques are well established and known to help in many situations but have generally been considered too complex to implement in a low cost terminal. In accordance with a first aspect of the invention, there is provided a fixed wireless access arrangement comprising at least one base station in communication an out station, wherein the out station has at least two antennas, and wherein the signals from the antennas are assessed relative to a threshold and wherein the strongest output signal is selected and wherein the output signals from the other antenna is selected only when it contributes to the carrier-to-noise ratio. In accordance with a further aspect of the invention, there is provided a method of operating a fixed wireless access arrangement, wherein secondary antennas are employed only when the secondary antenna contributes to the carrier-to-noise ratio of the system.

Figure 1: A Multiple Access System



FS = Fixed Station
BS = Base Station

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Figure 2 - Terminal Block Diagram

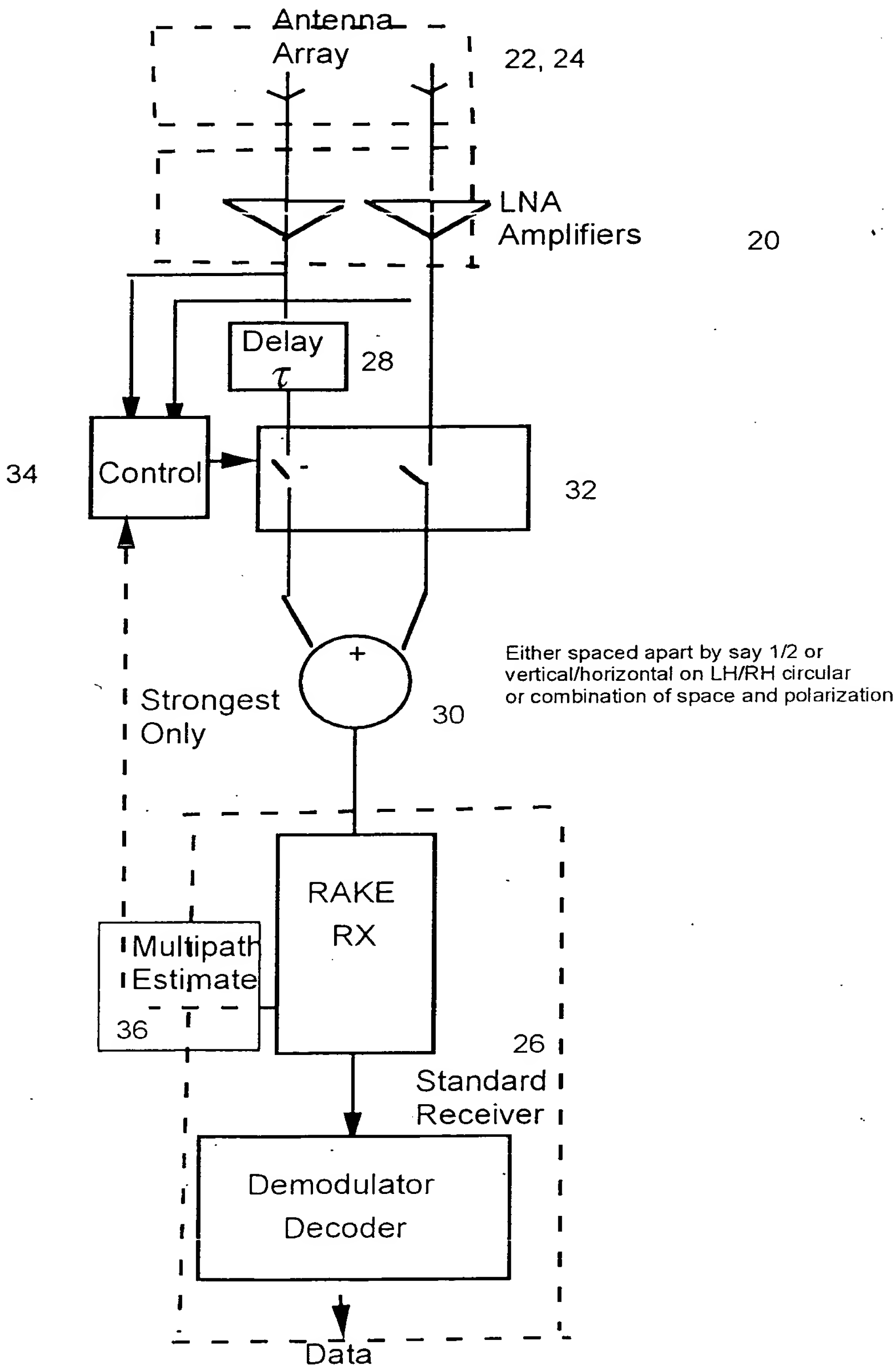

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Figure 3: A1 begins off target then A2 becomes channel.

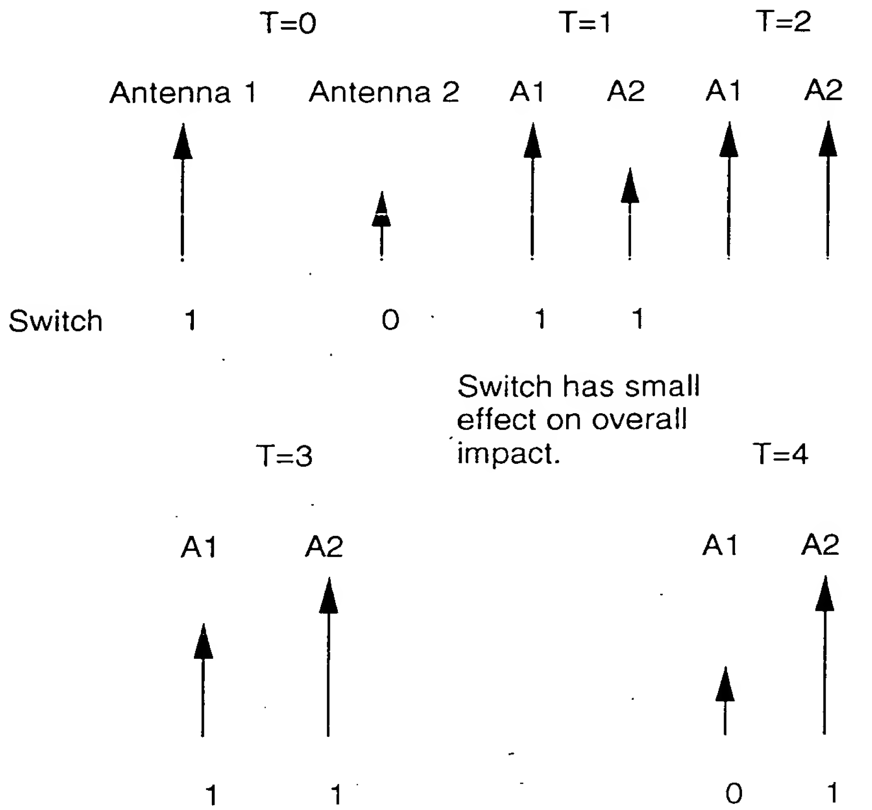

Figure 4: Al target then A2 contributres then fades again

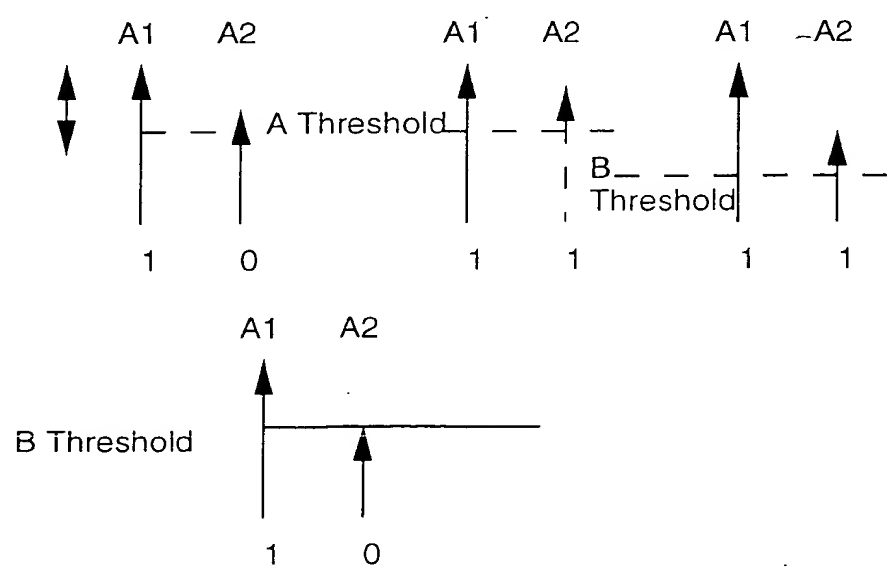

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Figure 5 - Terminal Block Diagram

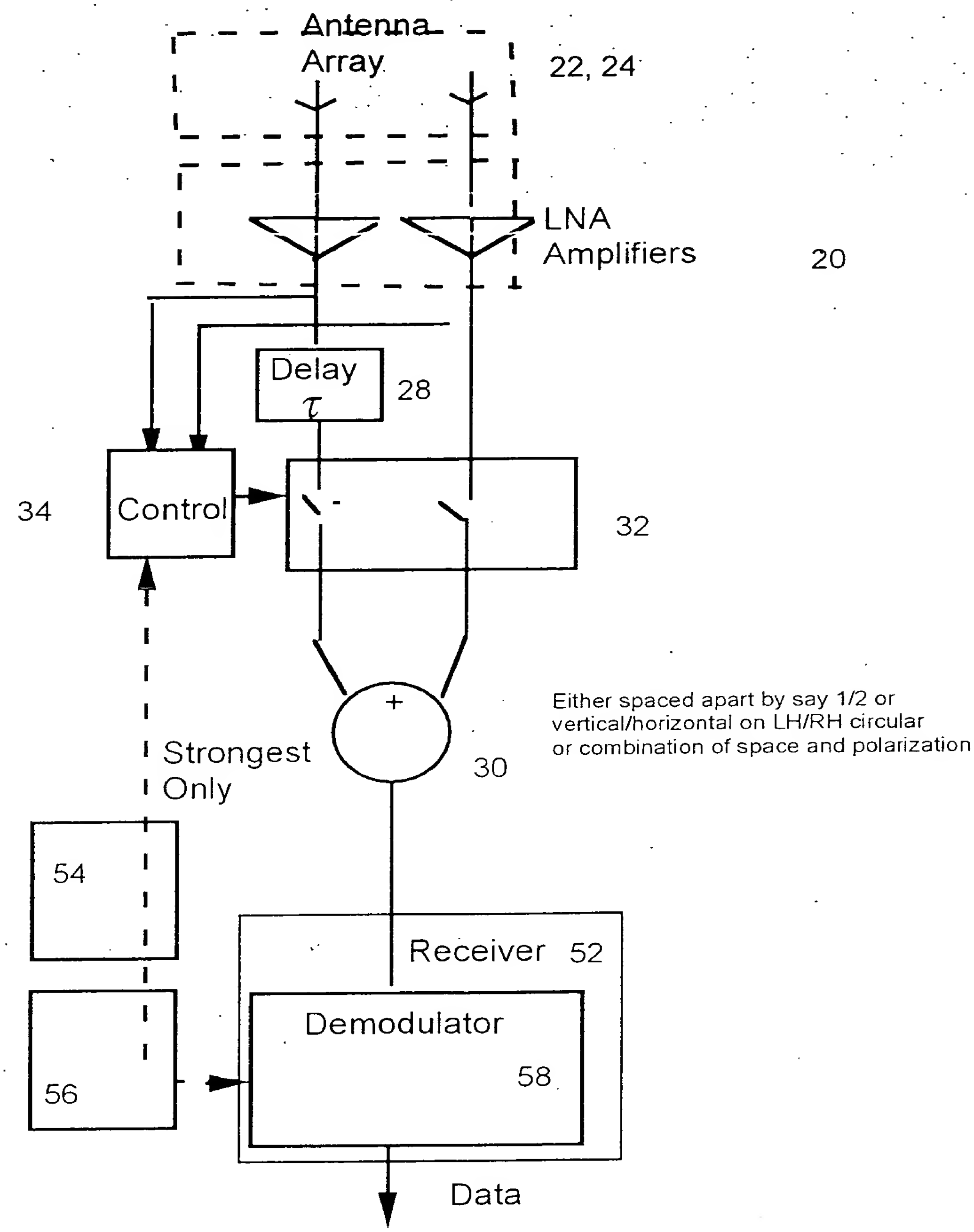

Figure 5a

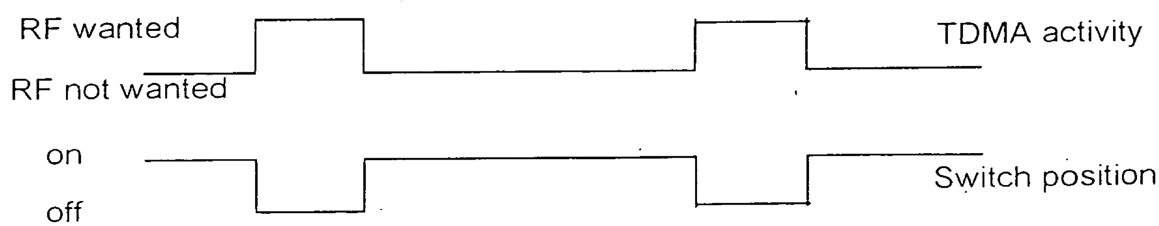

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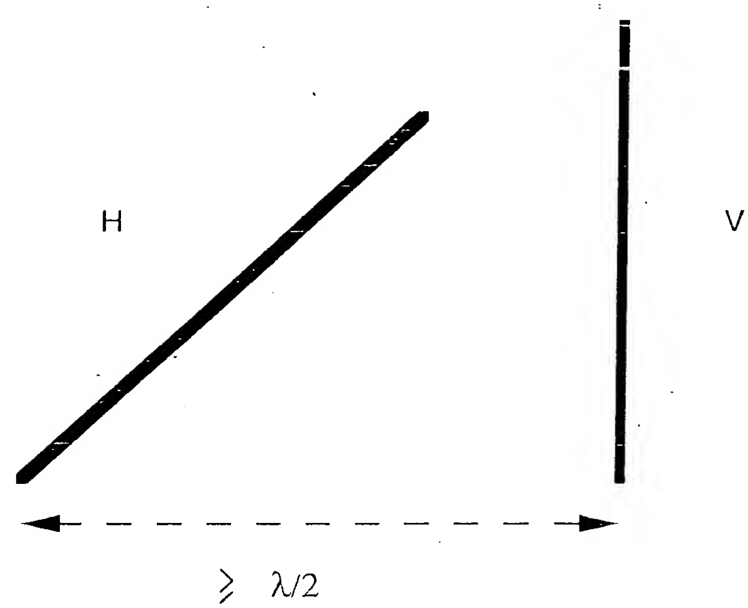
Figure 6



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